SURVEY OF JAPANESE SHIPYARDS

MARAD SPONSORED PROJECT
FOR THE TRANSFER OF

JAPANESE SHIPBUILDING TECHNOLOGY

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P. E. JAQUITH

NOVEMBER 1979

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SURVEY OF JAPANESE SHIPYARDS

References:

(a) PEJ memo #PPC-754, Outfit Design, Planning and Construction, dated 9-27-79

(b) Outfit Planning by L. D. Chirillo, Todd Pacific Shipyards and C. S. Jonson, Science Applications - A manual on the Advanced System of Outfit Design, Planning & Construction used by the IHI Shipyards in Japan

(c) Improving Shipyard Production with Standard Components and Modules by Joshinobu Ichinose, IHI Shipyards of Japan - A SNAME Paper on the use of Design and Production Standards at IHI

(d) A Survey of Japanese Shipyards, RRR, HDH, WRM Trip Report, dated September 1971

"(e) outline of Management, Design and-Production Technology in Mitsui Tamano Works (Shipbuilding Division), dated 11-2-79

(f) Zone Outfitting in Kure Shipyard of IHI, dated November 1979

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SURVEY OF JAPANESE SHIPYARDS

1.0 Executive Summary

1.1 Background

A survey of Japanese Shipyards was conducted from October 29 to November 26, 1979 in support of a MarAd sponsored project for stimulating the U.S. Shipbuilding Industry to improve productivity. In brief, the objective of this project was for a team of (6) individuals having broad shipbuilding exerience to visit Japanese Shipyards for the purpose of identifying specific areas and follow-on projects where Japanese Shipbuilding Technology can be transferred to the U.S. Shipbuilding Industry with MarAd assistance. The emphasis of this project is in the area of Systems and Procedures, Management and Organization Techniques, and Computer Software as opposed to Hardware Systems requiring large capital investment.

The shipyards visited were selected based upon IITRI contacts with the leading shipbuilding companies in Japan. The shipyards and organizations visited are listed below:

Mitsui Head Office -	Tokyo, Japan
Mitsui Shipyard -	Chiba, Japan
Mitsui Shipyard -	Tamano, Japan
IHI Shipyard	Kure, Japan
IHI Shipyard	Aioi, Japan
IHI Shipyard	Tokyo, Japan
NKK Shipyard	Shimizu, Japan

With the exception of the Mitsui Chi22a Shipvard, all of the shipyards”visited were old yards that had been modernized. In all cases, the shipyards were building orders of (1-4) vessels of non-standard design-so a good comparison with the U.S. Industry exists.

1.2 Key Observations

Production thruput, even at the reduced levels dictated by world shipbuilding demand, was high by U.S. Standards. Direct labor manhours and construction schedules were approximately one half or less of U.S. practice. Based upon observations made in the six Japanese Shipyards visited, I believe the primary reason for this performance is a high degree of rationalization* in the areas of work organization, design, planning material control, facilities and tooling. These observations will be further described in this section and in sections 2.0 thru 6.0 of this report.

(A) Scheduling and Control

- A typical Japanese Milestone Schedule for the construction of a new design non-standard cargo, bulk, container or RO/RO Ship is as follows:

Contract Award to Start Fab	- 6 Months
Start Fab to Keel	- 2 "
Keel to Launch	- 3 "
Launch to Delivery	-3 "
	= Months

- Scheduling and control of both the Front End and Production Phases are simplified by the common zone or area orientation of the design, planning, scheduling, labor/material control and production.

- Although schedules are simpler and in less detail than BIW, control appears excellent in all areas.

(See Section 2.0 for further details.)

(B) Organization of Work

- The organization of work has been further simplified by the product or zone orientation of both the design and production organizations. A tYPical product or zone breakdown used with minor modifications im both design and production is as inollows:

*Modernized based upon the principals of Hull Block Construction and Zone Outfitting.

- Hull Construction (Hull Fabrication, Assembly and Erection)

  Accommodation Outfitting (Outfitting of Accommodation Spaces)

- Deck Outfitting (Outfitting of Cargo “ and Deck Areas)

- Machinery Outfitting (Outfitting of Machinery Spaces)

  Electrical Outfitting (All Electrical Outfitting)

- Outfit parts, other than piping, are sub-contracted locally thus simplifying internal control.

- All production work in the fabrication, assembly/preoutfit, and on board outfit phases has been organized by zone or area through the use of working plans and material lists ‘(Pallet Lists). Systems take precedence over zones at the time of Shipboard’ Testing.

- A similar approach has been taken by IHI Tokyo in their construction of the DDH, a 5200 Ton Twin Screw Destroyer.

  (See Section 3.0 for further details.)

(c) <u>Design Approach</u>

- The basic or contract design is more complete than U.S. practice and is accomplished by the Tokyo Head Office.

- The completion of functional design, key plans and calculations, and the development of working plans is normally accomplished in the yard design office.

- Outfitting working plan development has been streamlined thru the use of “Composit Outfit Arrangement Drawings”. The use of the Composit Outfit Arrangement Plan is a key element in the reduced working plan development time achieved by Japanese Yards vs U.S. practice.

- Both functional and working plan development are greatly assisted thru the use of comprehensive standards* and extensive experience on previous vessels.

- The design is developed based upon extensive planning and production input early in the design process. This again is assisted by standards.

- The working plans and material lists (Pallet Lists), provide a common documentation for design, planning, scheduling, labor/material control and production.

  (See Section 4.0 for further details.)

(D) Shipbuilding Standards

- Both IHI and Mitsui have developed extensive standards for use in functional design, detail design, planning, production, and quality control.

- Design and material standards start at the level of individual components and pieces of raw material (such as BIW is developing) and include progressive tiers to the level of standard machinery arrangements and system diagrams for various standard "ships and various sizes of standard steam or diesel power plants.

- This approach has provided the yards a formalized way of documenting their experience and of developing new design or production processes documented in a manner that they can be modified as required to suit new owner or service requirements.

- The use of standards is a key element in the significantly reduced design and production costs and schedules achieved by Japanese Yards vs U.S. practice.

  (See Section 5.0 for further details.)

*Documented Standards or Guidance Data for use in the areas of functional design, detail design, planning, production and quality control.

(E) Preoutfit Approach

- Outfit installation as developed by Japanese Shipyards is broken into three stages:

  On Unit (called packaging by BIW) - package or module outfitting of components, piping, grating etc. Packages are often multi-system and include multiple disciplines.

  On Block (called unit preoutfit by BIW) structural block preoutfit similar to that accomplished by BIW.

  On Board (called outfitting by BIW) - installation of the remaining material on board ship. The work is packaged by logical area vs conventional system.

- On block preoutfit levels observed in Japanese Yards were very similar to BIW practice on the Matson/FLI contracts where comparable blocks were observed.

- On unit preoutfit provides Japanese Yards a significant advantage-in areas not subject to on block preoutfit (i.e. engine room and weather decks) vs current BIW practice.

- IHI stated the following savings for on unit and on block preoutfit:

  on unit vs. on board = 70% savings
  on block vs, on board = 30% savings

- pictures of the DDH construction viewed in IHI Tokyo indicated limited use of on unit preoutfit and extensive on block preoutfit. As BIW uses larger blocks on the FFG, ouT preoutfit levels exceeded theirs.

  (See Section 6.0 for further details)

(F) Dimensional Control

- Structural dimensional control was very advanced in the yards visited. Midship units were fabricated neat with no stock, and most bow and stern blocks were cut neat at assembly.

- The dimensional control approach was described as the monitoring and control of each fabrication, sub-assembly and assembly operation based upon worker, supervision and quality control inspection and documentation.

- Dimensional control standards were stated to be based upon experience and statistical projections of cumulative errors.

- This system is considered key in their low assembly and erection costs and time as fit up was excellent and rework was minimal.

(G) Computer Aided Design

- Computer aided pipe detailing was in use in all yards although in many yards pipe fabrication was not automated. System capabilities appear similar to RAPID which will become available from IITRI this year.

- Computer aided structural design and lofting was in use in all yards although plate cutting in many yards was still by “Electro-Photo-Marking” using optical projection. System capabilities appear similar .to AUTOKON ’76 or ’79 plus Parts Definition, a new AUTOKON compatible system being developed under IITRI.

- Computerized control of both *raw* and fabricated material was in use in all yards. Computer aided generation of material lists (Pallet Lists) was used in Engineering to assist this.

- Seabird, an advanced interactive commter aided design system using a data base concept, had been developed by IHI. This system is no longer in use due to an excess of experienced designers and the cost to update it to new computer technology. This system, when in use, resulted in a 30% savings in design cost and time and IHI states they will use it in the future when business improves.

- The advantage stated for the above computer applications was reduced design time and costs .

1.3 Conclusions and Recommendations

Although many of the observations were similar to those already described in references (a-d): I feel the trip was most informative as a greater understanding of the principals was achieved. Based upon these observations, I am convinced that BIW has been moving in the right direction during the last ten years and particularly during the last four years. Although several key U.S. Shipyards (National Steel, Avondale, Livingston and Sun Ship) have already initiated studies of IHI's or other leading shipbuilders' methods, I feel that BIW may be in an unique position to properly evaluate and implement this advanced technology.

Assuming a high probability of BIW being involved in new ship design and construction in the early 1980:s, I feel the adoption of selected Japanese approaches offers significant schedule and cost advantages to BIW. In light of the above, the following recommendations are made:

(A) BIw should establish a project team to carefully reviewJapanese procedures and to recommend implementation where found appropriate. In this regard, particular emphasis should be placed in the following areas:

- Schedule and Control
- Organization of Work
- Design Approach
- Shipbuilding Standards
- Preoutfit Approach

(B) BIW, as manager of the MARAD Shipbuilding Standards Program, should push aggressively for an expanded standards program. Specific emphasis should be placed on a long range program for standards development and the development of functional design standards for low speed diesel power plants.

(C) In reviewing Japanese procedures and developing an expanded U.S. Shipbuilding Standards Program, BIW should closely observe the Livingston Program and other existing and follow-on MARAD funded projects that are already planned in these areas.

(D) BIW should send a follow-on team of Key Management Personnel to Japan to gain further familiarization and understanding of Japanese design, planning and production procedures.

(E) If required at a later date to assist in implementing new approaches, BIW should consider the use of Key Consultants from Japanese Firms such as IHI and Mitsui.

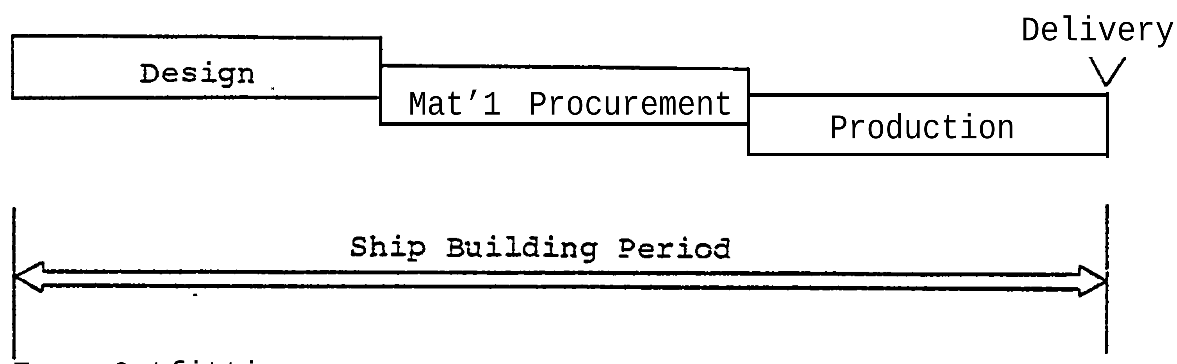
2.0 Schedule and Control

2.1 A typical Japanese Milestone Schedule for commercial construction is shown in Exhibit 2-I, page 11. A more detail milestone schedule for a Mitsui buik carrier is shown in Reference (e), page 2-4.

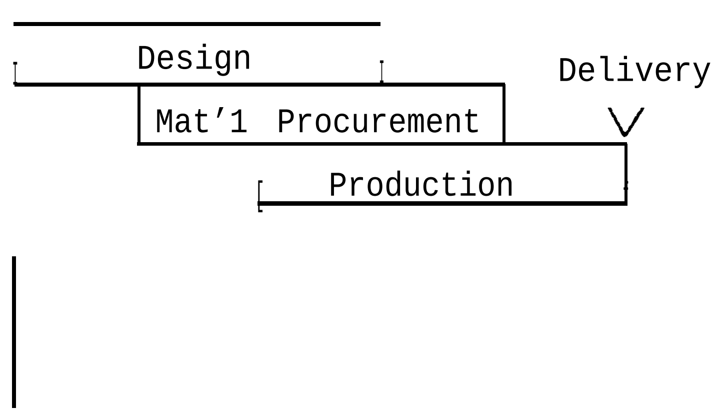
2.2 A typical IHI Schedule for a 5200 Ton Destroyer is shown in Exhibit 2-2, page 12.

2.3 In order to support the very short shipbuilding periods illustrated in Exhibit 2-1 and 2-2, Japanese shipbuilders have found it necessary to parallel the design, material procurement and production phases as illustrated below:

Conventional Outfitting



Zone Outfitting



NOTE : Parallel design material procurement and production is more readily scheduled-and controlled with a product oriented detailed design.

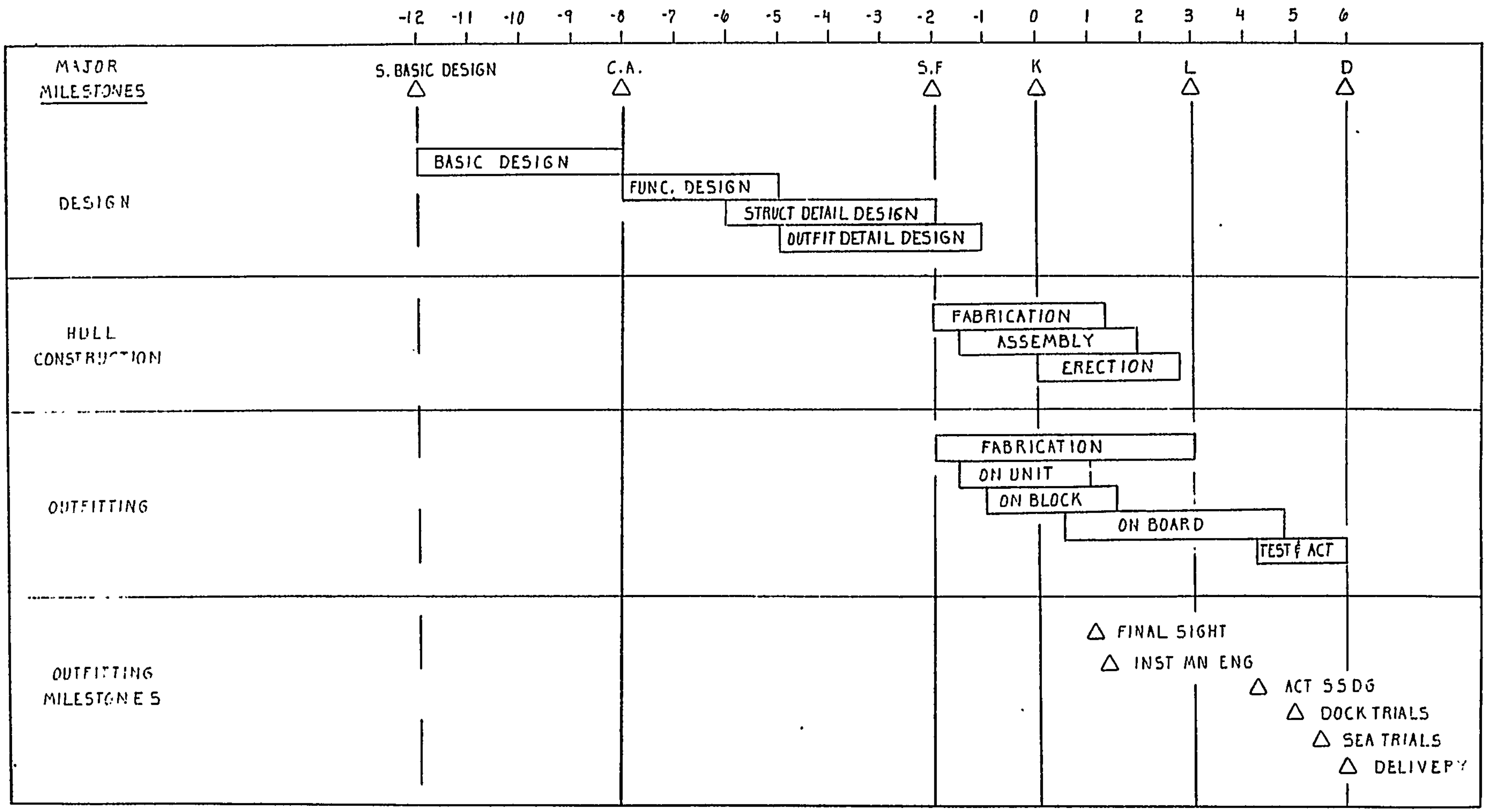
2.4 Japanese Shipbuilding Schedules are normally Gantt Charts or simple lists. IHI, Kure personnel, indicated that they had tried PERT/CPM Networks and found them too inflexible for the shipbuilding environment. They did, however, indicate that they had used a computer network analyses system (PMS) for the design and production of a floating power and pulp plant for the Amazon River. The reason given for using network analyses on the latter project is the fact that their previous shipbuilding experience did not directly relate and they needed a more detailed analysis to identify critical paths and establish schedules.

2.5 Scheduling and control of both the Front End and Production Phases are simplified by the common zone or area orientation of the design, planning, scheduling, labor/material control and production.

2.6 Although schedules are simpler and in less detail than BIW, control appears excellent in all areas.

2.7 Additional explanations and examples of Japanese Shipbuilding Schedules can be found in Reference (e), pages 5-4 to 5-11, and in Reference (f), pages 30-33.

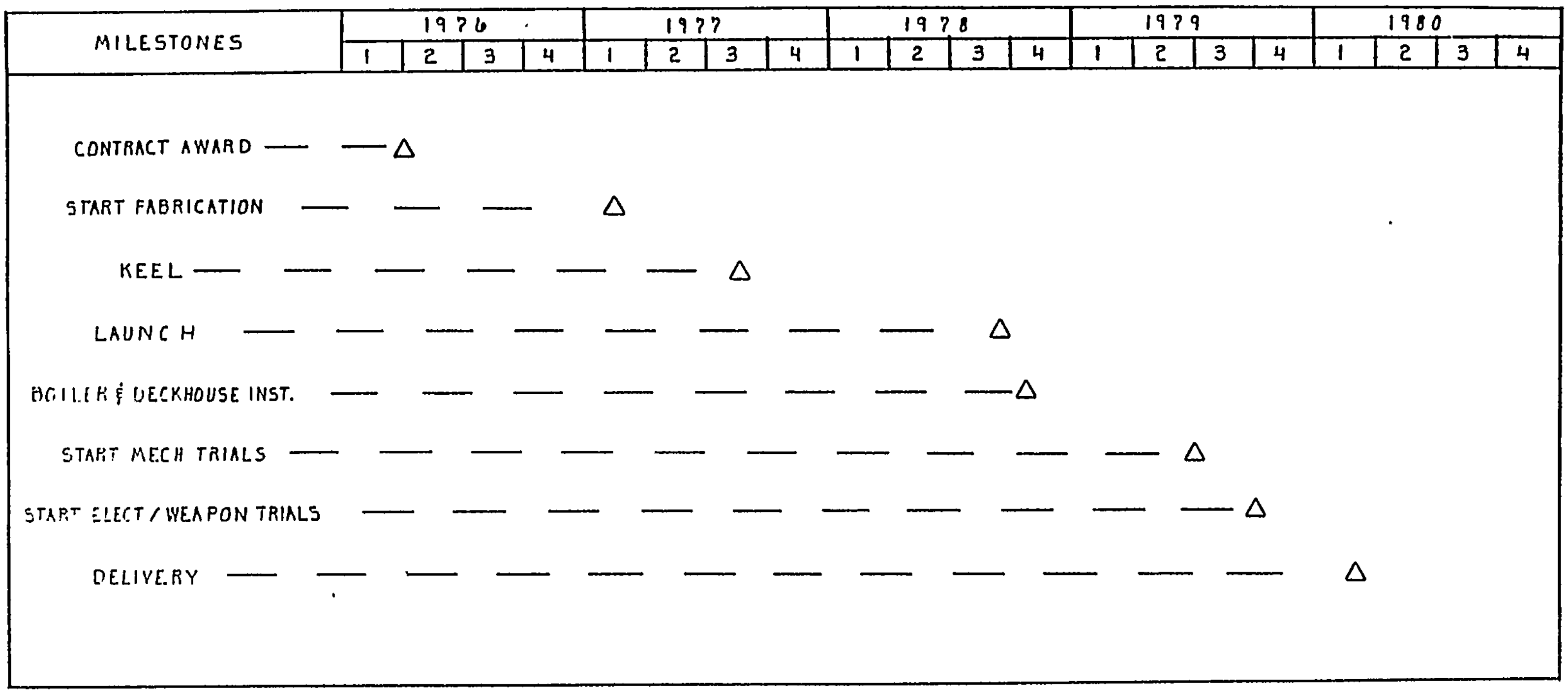
TYPICAL JAPANESE MILESTONE SCHEDULE FOR COMMERCIAL CONSTRUCTION[1]



NOTES: (1) TYPICAL WITH MINOR ADJUSTMENTS FOR A NON-STANDARD CARGO, BULK, CONTAINER, OR RO/RO SHIP.

(2) BASED UPON REF (E) AND NOTES ON IHI

TYPICAL IHI SCHEDULE FOR A 5200 TON DESTROYER



NOTES: (1) TYPICAL FOR A FIRST OF CLASS HAVING SIMILAR MACHINERY TO A PREVIOUS CLASS

(2) LIMITED ON UNIT AND EXTENSIVE ON BLOCK PREOUTFIT WAS USED ON 1ST HULL

(3) BASED UPON IHI NOTES ON TOKYO D.D.H. CONSTRUCTION

3.0 Organization of Work

3.1 The organization of a typical Japanese Design or Outfitting Production Division is product or zone oriented. This is shown for commercial shipbuilding by Exhibit 3-1 and 3-2, pages 15 and 15. A modification of this production outfitting division organization is shown for IHI's Tokyo Yard construction of a 5200 Ton Destroyer by Exhibit 3-3, page 17.

3.2 The Pallet (workpackage) is zone or area oriented in order to simplify scheduling and control of labor and material. This is illustrated by Exhibit 3-4, page 18.

3.3 The following guidelines have been developed by ZHI to assist in defining Pallet breakdowns:

a. On block outfitting for material preassembled into a unit.

b. On block outfitting after a steel block is turned over for material.preassembled into a unit.

c. On board outfitting for material preassembled into a unit.

d. On block outfitting for material to be installed piece by piece.

e. On block outfitting after a steel block is turned over for material to be installed piece by piece.

f. On board outfitting prior to an area being closed in by an overhead block.

5* On board outfitting by zone or area prior to system tests (or other key events such as launch, trials, etc.) .

h. On board outfitting general category for items such as spare parts and touch Up.

3.4 The organization of outfit in the engine room lower level of a typical diesel machinery space is illustrated as follows:

5 Structural Blocks

- 3 to 4 Pipe Units

10-12 Machinery Units

3.5 The number of Pallets or MLPs (Pallet Material Lists) for typical IHI standard vessels are shown in Exhibit 3-5, page 19.

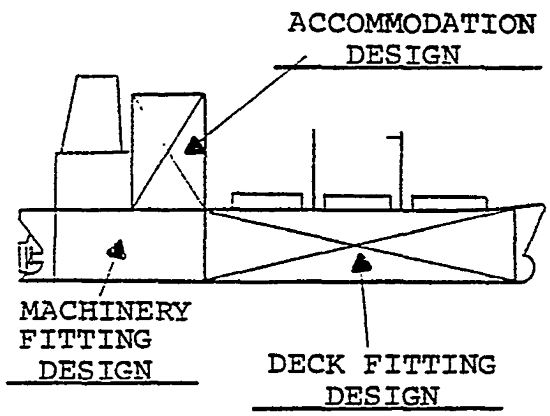
3.6 The transition from zone or area construction to system completion in the piping area takes place at testing. The testing of commercial ship piping systems is normally done by zone as a result of the zone orientation of the outfitting crafts and to support schedule completion of individual zones.

3.7 Outfit parts, other than piping, are subcontracted locally thus simplifying internal control.

IHI KURE

ORGANIZATION OF DESIGN DIVISION

- SHIP DESIGN DEPT.
  - BUSINESS ADMINISTRATION
  - DESIGN PROJECT GROUP
  - HULL STRUCTURAL DESIGN
  - ACCOMMODATION DESIGN
  - DECK FITTING DESIGN
  - MACHINERY FITTING DESIGN
  - ELECTRICAL FITTING DESIGN
  - NAVAL VESSEL DESIGN

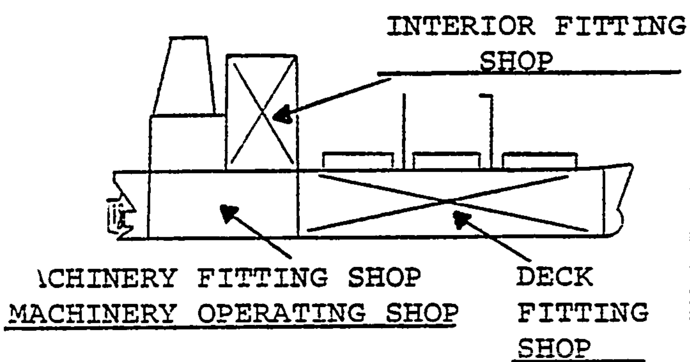


NOTE: ELECTRICAL FITTING DESIGN COVER ALL ZONES

IHI KURE

ORGANIZATION OF OUTFITTING DIVISION

- FITTING WORK SHOP
  - PRODUCTION PLANNING & ENGINEERING GROUP
  - PIPE FABRICATION SHOP
  - INTERIOR FITTING SHOP
  - DECK FITTING SHOP
  - MACHINERY FITTING SHOP
  - MACHINERY OPERATING SHOP
  - ELECTRICAL FITTING SHOP
  - PAINTING SHOP



NOTE: ELECTRICAL FITTING & PAINTING SHOPS COVER ALL ZONES

EXHIBIT 3-3

IHI TOKYO

ORGANIZATION OF OUTFITTING DIVISION

FOR NAVAL VESSELS

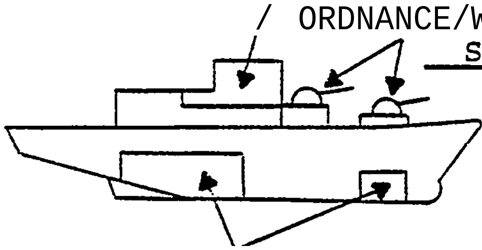
FITTING WORK SHOP

PRODUCTION PLANNING & ENGINEERING GROUP

- PIPE FABRICATION
- HULL (DECK) FITTING SHOP
- .MACHINERY FITTING SHOP
- MACHINERY OPERATING SHOP
- ELECTRICAL FITTING SHOP
- ORDNANCE/WEAPONS SHOP
- PAINTING SHOP

ELECTRICAL FITTING SHOP

/ ORDNANCE/WEAPONi SHOP



MACHINER= FITTING SHOP
" MACHINERY OPERATING SHOP

NOTES :

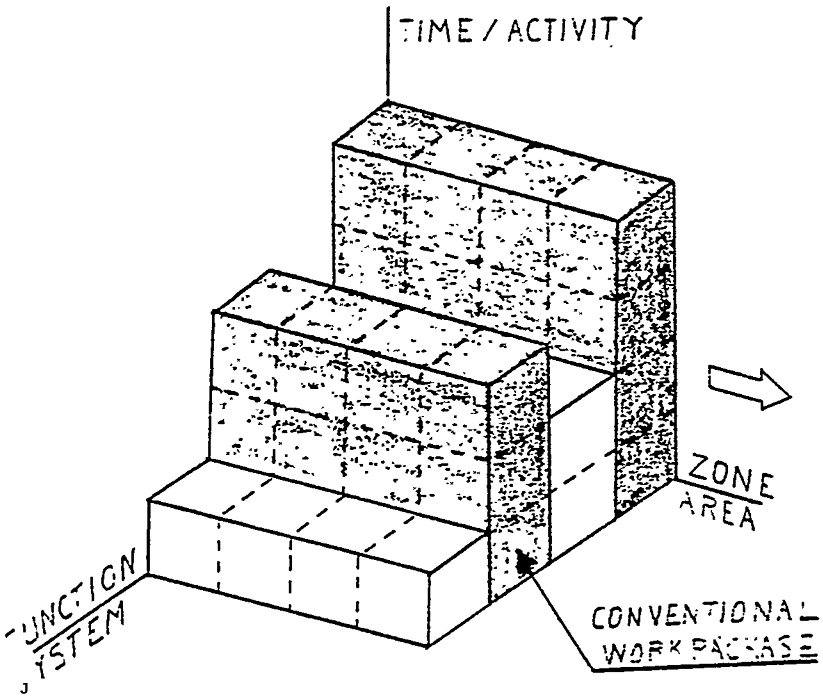
(1) ALL AREAS NOT MACH ., ELEC . OR ORD . ARE MANAGED BY HUIL FITTING SHOP

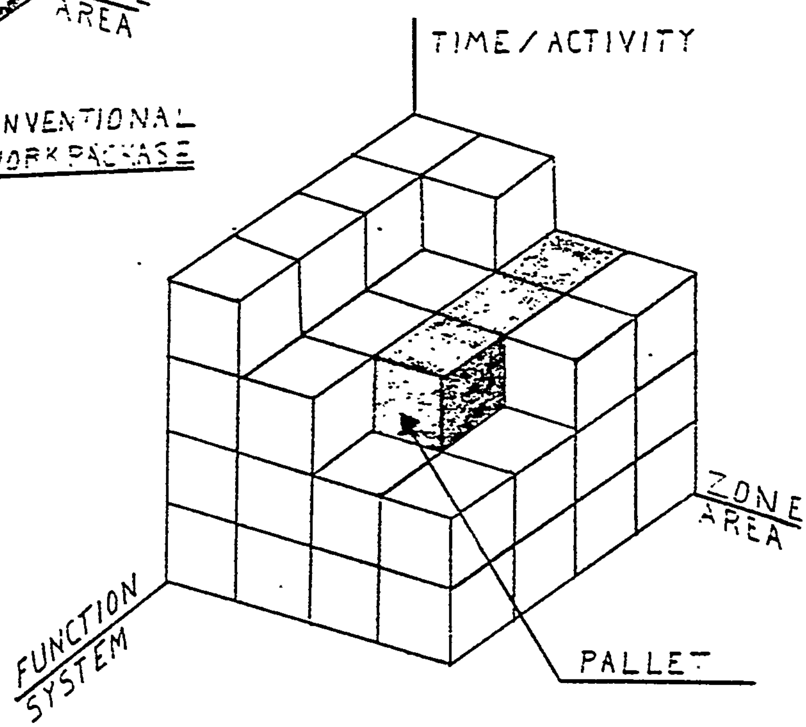
(2) PAINTING & ELEC. FITTING SHOPS COVER AIL ZONES

EXHIBIT 3-4

CONCEPT OF PALLETING

OR ZONE OUTFITTING





CONVENTIONAL OUTFITTING

CONVENTIONAL SYSTEM ORIENTED WORKPACKAGES CROSS MULTIPLE ZONES (AREAS) AND TIMES (ACTIVITIES) GIVING LIMITED CONTROL.

ZONE OUTFITTING

ZONE ORIENTED PALLETS CROSS MULTIPLE SYSTEMS BUT ALIGN DIRECTLY TO PRODUCTION WORK BEING ACCOMPLISHED BY ZONE (AREA) AND TIME (ACTIVITY) THUS GIVING GOOD CONTROL.

NO OF PALLETS OR .MFL'S (1) EXHIBIT 3-!

FOR IHI STANDARD VESSELS

KIND OF VESSEL	ZONE	ON BLOCK	ASS. UNIT	ERECT UNIT	ERECT	TOTAL	TOTAL UNITS
FREEDOM MK-II 15,000 TON MPC	ACC	34			408	442	-0-
	HULL OUTFIT	132	56	8	109	305	64
	MACH	66	30	49	107	252	79
	ELECT	90		44	82	216	44
	TOTAL	322	86	101	706	1215	137
FREEDOM 17,000 TON MPC	ACC	24			285	309	
	HULL OUTFIT	185		1	187	373	1
	MACH	32	17	45	227	321	62
	ELECT	11		19	52	82	19
	TOTAL	252	17	65	751	1085	82
FORTUNE 20,000 TON MPC	ACC	69			159	228	
	HULL OUTFIT	138		2	63	203	
	MACH	35		81	110	226	
	ELECT	33			53	121	
	TOTAL	275		83	420	773	
B.C. 60,000 TON	ACC	87		2	239	325	2
	HULL OUTFIT	431	116	33	106	636	149
	MACH	32	18	78	144	272	96
	ELECT	46			173	219	
	TOTAL	596	134	113	662	1505	247
O.C. 168,000 TON	ACC	83		5	262	350	5
	HULL OUTFIT	515	94	44	112	765	138
	MACH	55	23	93	171	342	116
	ELECT	49			201	250	
	TOTAL	702	117	142	746	1707	259
VLCC 250,000 TON	ACC	58	18	5	234	315	23
	HULL OUTFIT	532	136	101	151	920	237
	MACH	84	5	106	208	403	111
	ELECT	40			196	236	
	TOTAL	714 I	159	212	789	1874	371
VLCC 250,000 TON	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	HULL OUTFIT	487	124	83	139	833	207
	MACH	88	32	115	190	425	147
	ELECT	85			223	308	
	TOTAL	756	175	215	827	1973	390

(1) MATERIAL LIST FOR PALLETS / WORK PACKAGES

4.0 Design Approach

4.1 In Japanese Shipyards the design effort is divided into four stages:

- Basic Design - Preliminary design calculations, general arrangement, machinery arrangement, midship section, scantling plans, and system diagrams. (Performed in the Tokyo Head Office.)

- Function Design - The completion of key drawings such as arrangements, system diagrams, structural scantling plans, etc.

- Detail Design - The conversion of functional design information into zone or area oriented structural and outfit working drawings.

- Work Instruction Resign - Structural lofting, pipe sketching, and the development of other detail fabrication sketches required to fabricate or purchase small subassemblies.

4.2 The basic or contract design is more complete than U.S. practice and is accomplished by the Tokyo Head Office.

4.3 The completion of functional design, key plans and calculations, and the development of working plans is normally accomplished in the yard design office.

4.4 Piping and other system diagrams are developed in schematic form by deck level similar to U.S. practice. Piping diagrams are complete in all respects and along with the machinery arrangements are the only piping drawings submitted for agency approval. The piping diagrams are used in conjunction with machinery arrangements to determine the pipes system lengths for the purpose of sizing and matesial calculations.

4.5 Outfitting working plan development has been streamlined thru the use of “Composite Outfit Arrangement Drawings”. The use of the Composite Outfit Arrangement Plan is a key element in the reduced working plan development time achieved by Japanese Yards vs. U.S. practice. This is illustrated by a Flow Chart of Outfitting Working Plan Development, Exhibit 4-1, page 23.

4.6 A description of Outfitting Working Drawings or Composite Outfit Arrangement Drawings is as follows: ,

Engine Room Lower Level - Drawings include foundations; piping; grating framework, plating, and handrails; piping supports; and ladders.

Deck Piping - Drawings include piping; “ grating framework, plating, and handrails; ladders; deck fittings; piping supports; and foundation installation.

Forecastle Deck - Rrawings.include deck fittings; equipment and foundation installation; grating framework, plating and handrails; piping: and piping supports.

Accommodations - Three drawings were used; a) piping, ventilation, ladders, equipment and foundation installation; b) joiner installation and c) electrical” installation.

4.7 The outfitting composite drawings reviewed at all the shipyards were not sophisticated drawings. The piping was shown as one line although the flanges appeared to be shown full size. The composite drawings did include elevations, sections and details and the drawings were coded with symbols or by shading to indicate the installation stage, i.e. on unit, on. block, or on board.

4.8 Typical structural working plans include deck, side shell, web frames, etc. for the complete block or for a group of similar blocks. Structural working plans do not include foundations which are issued on a separate book plan by area or zone.

4.9 Material is ordered in progressive stages throughout the functional design, detail design, and work instruction desiqn phases in order to suit material lead times. Long-lead material is ordered by the Tokyo office during the basic design phase. This is illustrated by Exhibit 4-2, Outline Process of Pallet Design, page 24.

4.10 The design is developed based upon intensive planning and production input early in the design process. This is illustrated by the Outline Process of Pallet Design, Exhibit 4-2, page 24.

4.11 Both functional and working plan development are greatly assisted thru the use of comprehensive standards and extensive experience-on previous vessels.

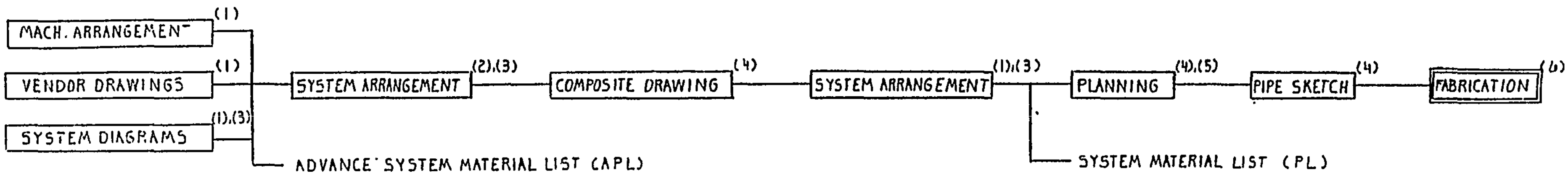
4.12 The working plans and material lists (Pallet Lists) provide a common documentation for design, planning, scheduling, labor/material control and production.

4.13 The Japanese approach to design, described in the above paragraphs, is slightly different from that described in Reference (d). The primary difference is the use of multi-block structural drawings and area outfitting composite drawings that do not reflect a single stage of construction or a single structural block or outfitting unit. This change in approach took place during the middle 70's, either due to lack of design staff to prepare the more costly unit or block oriented drawings or as a result of economy measures taken'after the decline in shipbuilding. The working drawings viewed appeared fully adequate for the purpose of supporting production installation.

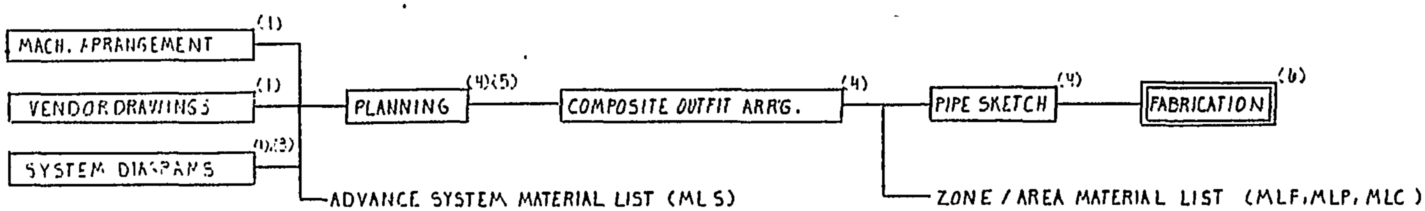
4.14 Additional explanations and illustrations of the Japanese design process can be found in Reference (e) pages 3-1 to 3-8 and in Reference (f) pages 7 thru 11.

FLOW CHART OF OUTFIT WORKING PLAN DEVELOPMENT
BIW VS. JAPANESE PRACTICE

BIW PRACTICE



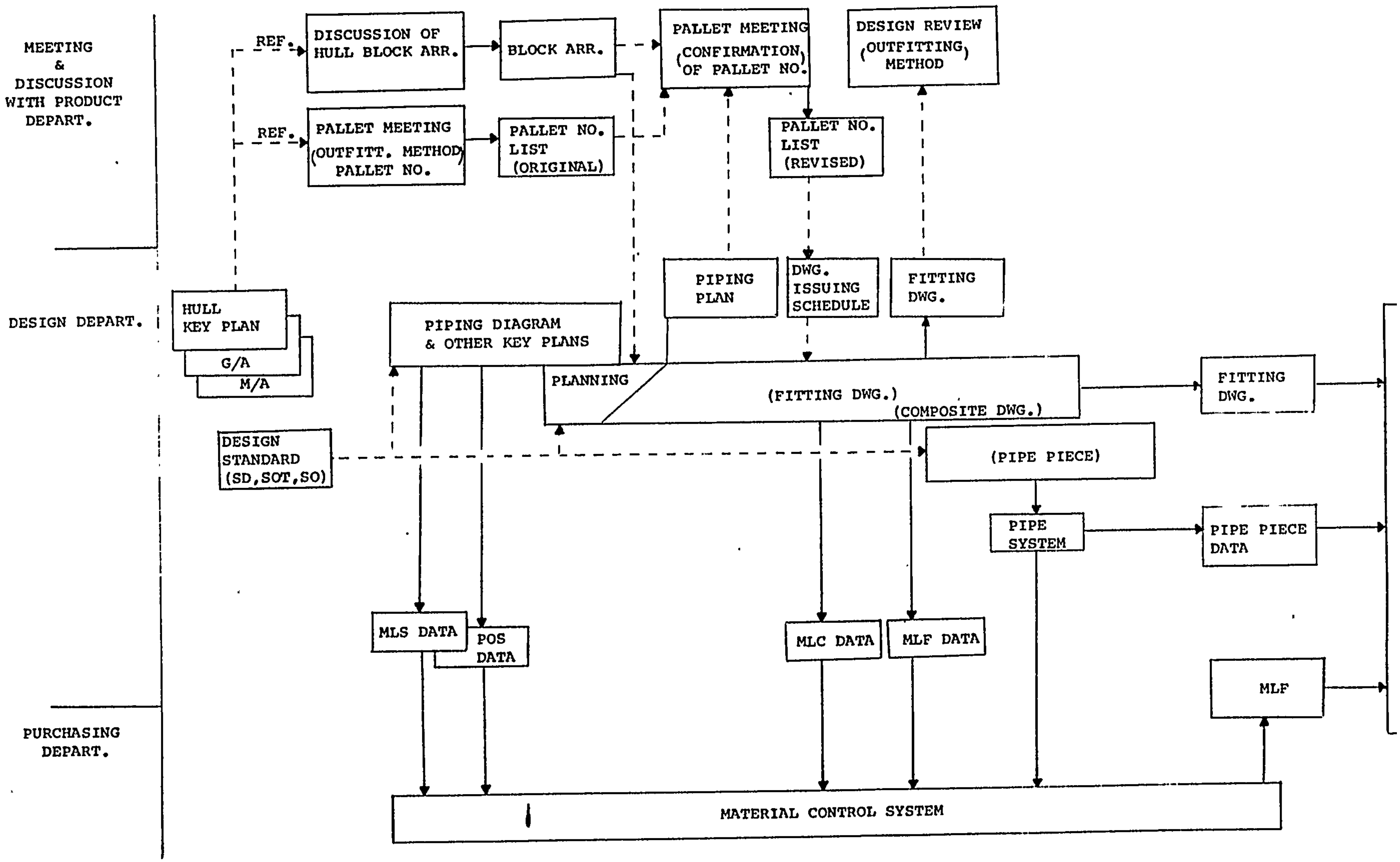
JAPANESE PRACTICE



NOTES:

(1) SUBMITTED FOR APPROVAL
(2) OMITTED ON RECENT WORK
(3) PREPARED BY SYSTEM/ HULL
(4) PREPARED BY ZONE/ AREA
(5) PLANNING OF HULL BLOCKS (UNITS) AND MACHINERY/ OUTFIT UNITS (PACKAGES)
(6) FABRICATION BY ZONE/ AREA/ UNIT

OUTLINE PROCESS OF PALLET DESIGN



5.0 Shipbuilding Standards

5.1 Both IHI and Mitsui have developed extensive standards for use in functional design, detail design, planning, production and quality control. This is illustrated by Exhibit 5-1, Table of IHI Standards, page 28.

5.2 IHI's design approach appears heavily oriented to the use of design standards which have been developed based on standard ship designs. See Exhibit 3-5, page 19for examples of standard IHI designs. Although these design standards are based on standard ship designs, they have been developed with the idea of solving a range of problems versus solving the specific design problems presented by the ship being designed. Mitsui, on the other hand, bases their designs on previous ships having similar engine types and power ranges. Neither IHI nor Mitsui appear to have a totally comprehensive documented set of standards covering all ship types. Standards for tanker and bulk ships appear to be very thoroughly developed, while standards for liner ships are less completely developed.

5.3 Both IHI and Mitsui have single main engine vendors for both low speed and medium speed diesel. IHI manufactures the low speed Sulzer and medium speed Pielstik engines while Mitsui manufactures the low speed B&W and a medium speed Mitsui engines.

5.4 Design and material standards start at the level of individual components and pieces of zaw material (such as BIW is developing) and include progressive tiers to the level of standard machinery arrangements and system diagrams for various standard ships and various sizes of standard steam or diesel power plants

5.5 The design of system modules using IHI functional design standards is illustrated in Exhibit 5-2, page 29. In this case, the design standards have allowed for alternative system capabilities and the designer selects from these alternatives to create the functional and working drawings for a new ship design.

5.6 An example of machinery component standards is illustrated by Exhibit 5-3, page 30. These standards appear to have been developed to a range of requirements instead of being designed axound a specific ship type.

5.7 According to IHI, Kure personnel, standards have been developed to reflect the highest quality based on new requirements and reflecting the experience of the past. The use of standards is sold to the owner, during technical negotiations prior to contract award, based on the principals of proven service experience, reduced delivery time and reduced cost.

5.8 Functional design standards for a 60,000 ton bulk carzier engine room design included the following:

Engine Room arrangement based on a single engine type with alternative number of cylinders.

- Machinery arrangement including plan, elevation and section.

A list of key equipment including alternate vendors except for the main engine.

All system diagrams.

An arrangement of machinery units or outfit packages:

Machinery module designs.

Parts lists for individual systems and machinery modules.

NOTE : The majority of machinery units or outfit packages shown for this design were based on standard machinery modules which are system oriented. Example, lube oil purification, fuel oil treatment, jacket water heat exchanges, etc.

5.9 IHI personnel indicated that they have previously forwarded-to BIW, as the MARAD Standards Program Manager, a proposal for technical assistance in the area of standards development. This proposal should be carefully reviewed, although, at this point, Mr. Harnada of IHI, indicates that the question of selling IHI's Standards or Assistance in Standards Development is a question that requires complete review by IHI Top Management.

5.10 Mitsui design standards, in the form of design manuals and design check lists, were reviewed. These design standards provides substantial guidance to designers in the form of partial system diagrams, tables or graphs simplifying engineering calculations, check lists of items required to properly complete functional or working drawings, check lists of items required to ensure reduced costs in the production area and check lists, based on experience, of items causing either production problems or problems in the guarantee area.

5.11 This approach to standards has provided Japanese Shipyards a formalized way of documenting their experience and of developing new design or production procedures documentated in a manner that they can be modified as required to suit new owner or service requirements.

5.12 The use of standards is a key element in the significantly reduced design and production costs and schedules achieved by Japanese Shipyards vs. U.S. practice.

5.23 Additional explanation and examples Of Japanese practice in the area of shipbuilding standards can be found in Reference (c), Reference (e) pages 3-7 to 3-16, and Reference (f) pages 14 thru 19.

5.14 Although IHI appears to have moved further in developing comprehensive shipbuilding standards, I believe that both Mitsui and IHI should be considered as potential subcontractors to BIW and the U.S. Shipbuilding Industry for the development of a comprehensive standards program.

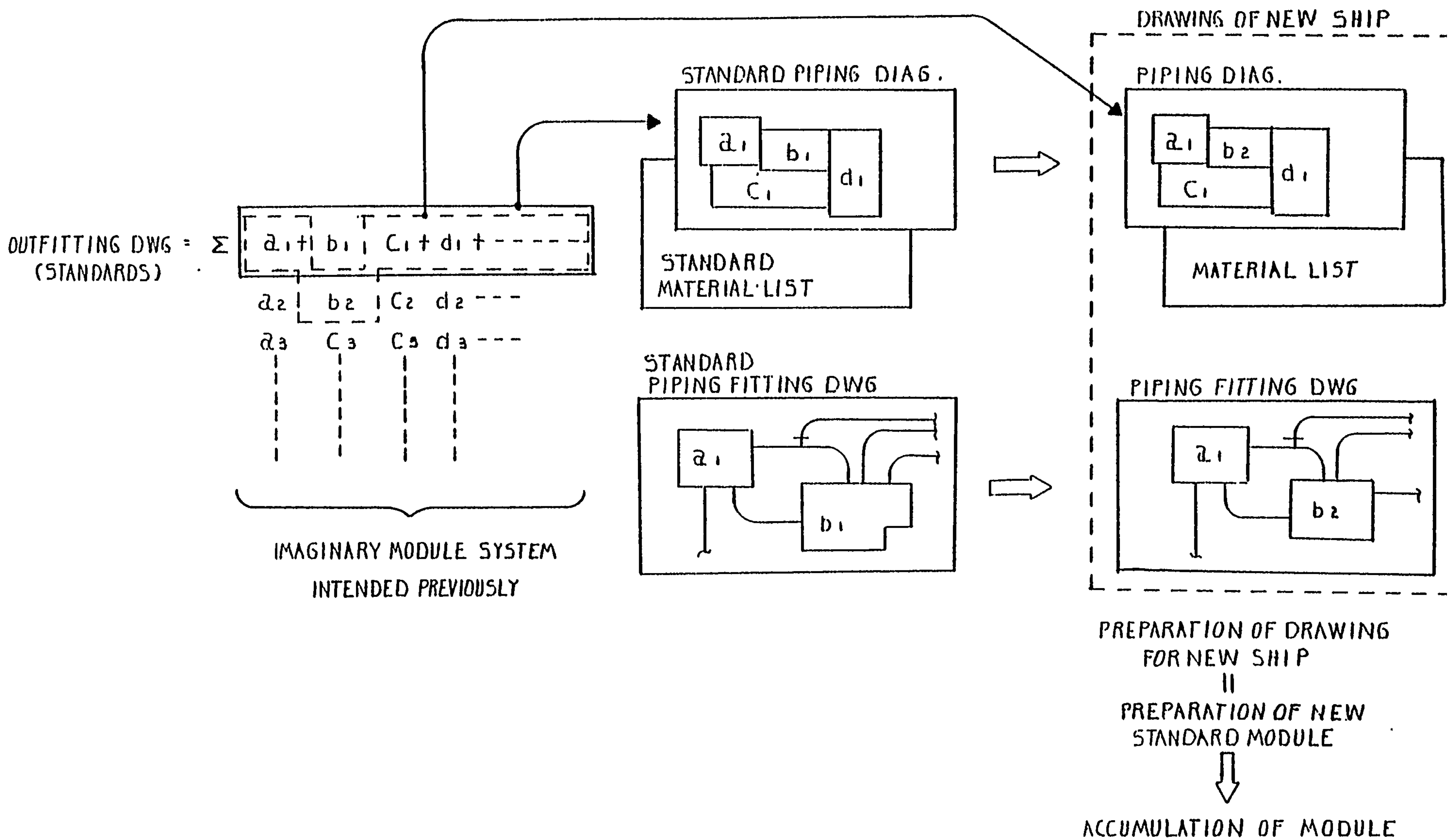
TABLE OF NUMBERS OF IHI STANDARDS

Classification of Standards				Nos.
IS	SO	Material standards	Common components	600
			Hull fittings	600
			Machinery fittings	200
			Electric fittings	200
		Sub-total		1,600
	SOT	Design standards		1,100
		Production eng. standards		2.00
		Inspection standards		200
		Sub-total		1,400
SD[1]		Machinery drawings (SDI[1])		1,200
		Component and fitting standard dwgs		350
		Other guidance drawings		350
		Sub-total		1,900
		Grand total		4,900

NOTE : (1) SDI Standards are standards where a change must be the result of a mutual agreement between IHI and a Vendor or Sub-Contractor.

EXHIBIT 5-2

OF SYSTEM MODULE DESIGN (IHI)



SAMPLE IHI MACHINERY COMPONENT STANDARD

Drain Pump (Large Size)						Mach. No.	M O 23	
						Type	V E C	
Cargo Pump Cap.		m3/h x m	3,500x125	4,000x125	3,500x150 4,000x150	4,000x150	4,500x150	5,000x150
Cargo Pump Sets		KWxrpm	3		3	4	4	4
Capacity		m3/h x m	70 x 90	80 x 90	90 x 95	110 x 95	130 x 95	70 x 100
Maker A	Model No.		EVZ 100	EVZ 130			EVZ130-2	EVZ-130
	Stand. Drwg. No.	SDx	440011360A	440011380			440011390	440011380
	Motor Capacity	KWxrpm	37 x 1800	45 x 1,800		55 x 1,800	75 x 1,800	45 x 1,80(
	Motor Model No.							
	Capacity range	m3/h x m	56 - 70 x 90	76 - 100 x 90	78 - 95 x 95	96 - 110 x 95	118 - 130 x 95	66 - 85 - 100
	Weight Pump	t						
	Weight Motor	t						
Maker B	Model No.		200 x 100-2YCSE-A	250 x 125 - 2VCDS - A			300 x 150-2VCDS-A	250 x 125-2VCDS-A
	Stand. Drwg. No.	S D I	440021730A	440021740A			440021390	440021740
	Motor Capacity	KWxrpm	37 x 1,800	45 x 1,800		55 x 1,800	75 x 1,800	45 x 1,800
	Motor Model No.							
	Capacity range	m3/h x m	51 - 70 x 90	80 - 100 x 90	95 x 95	91 - 110 x 95	130 - 140 x 95	70 - 85 x 100
	Weight Pump	t						
	Weight Motor	t						

6.0 Preoutfit Approach

6.1 Outfit installation, as developed by Japanese Shipyards, is broken into three stages:

- On Unit (called packaging by BIW) - package or module outfitting of components, piping, grating, etc. Packages are often multi-system and include multiple discipl-ines.

  On Block (called unit preoutfit by BIW) - structural block preoutfit similar to that accomplished by BIW.

  On Board (called outfitting by BIW) - installation of the remaining material on board ship. The work is packaged by logical area vs. conventional system.

6.2 On block preoutfit levels observed in Japanese Yards were very similar to BIW practice on the Matson/FLI contracts where comparable blocks were observed.

6.3 On unit preoutfit provides Japanese Yards a significant advantage in areas not subject to a block preoutfit (i.e. engine room and weather decks) versus cusrent BIW practice.

6.4 IHZ stated the following savings for on unit and on block preoutfit:

on unit vs. on board = 70% savings
on block vs. on board = 30% savings

6.5 The primary emphasis of Japanese Shipbuilders is based on maximizing the on unit preoutfit function Vs . the on block preoutfit function emphasized at BIW. The key advantages of this approach are as follows:

increased preoutfit levels
(8.0% piping vs. 55% at BIW)

reduced construction time due to parallel construction of structure and outfit.

reduced interface of pre-outfit and structural trades during steel assembly.

improved sequencing and control of work.

earlier application of labor and material than presently experienced at BIW.

6.6 In discussing the preoutfit of engine room lower level blocks (at IHI, Kure) that were similar to those structural blocks preoutfitted by BIW on the Matson and Farrell programs, the IHI, Kure personnel indicated preoutfit times of approximately 8-12 working days or roughly half at what BIW'S experience has been. The IHI personnel credited their preoutfitting of these very complex structural blocks to the extensive preassembly of piping, gratings, foundations and components that had been accomplished in the form of outfit units.

6.7 Pictures of the DDH construction viewed in IHI, Tokyo indicated limited use of on unit preoutfit and extensive on block preoutfit. As BIW uses larger blocks on the FFG, our preoutfit levels exceeded theirs.

7.0 Steel Construction

7.1 The block breakdown is defined very early in the contract and is a key input into the development of functional and detail design.

7.2 The steel plate and shape storage yards are *very* small compared to U.S. practice. Steel is normally delivered only one or two days prior to fabrication.

7.3 Steel fabrication and assembly shops are large and very well laid out. The area of steel assembly shops to ship erection area is greater than U.S. practice.

7.'4 Steel plates were typically laid out using optical projection in the electro-photo marking process. After layout, the plates were transferred to a cutting conveyor where they were cut to shape manually. Limited use of Numerical Control Cutting Machines was observed.

7.5 Steel shapes were laid out and burned to shape manually while moving on conveyors. The burning conveyors for plates and shapes were similar to those used at BIW. The use of conveyors in these applications eliminated crane and handling time.

7.6 Limited use of plate rolls and presses was observed. Heat lined bending of plates was observed in all shipyards visited.

7.7 Subassembly areas *were* large and well laid out. The subassembly of small floors and web frames was typically accomplished on a moving conveyor or on raised post mocks. The subassemblies for tanker web frames included staging clips, small lifting pads for use in assembly, and handgrabs or ladders for use during assembly and erection.

7.8 Directly after the flame planing or cutting of large plates to size, they were joined together and automatic welded with one side welding to form plate blankets.

7.9 Directly after the fabrication of deck, shell and bulkhead longitudinal, the longitudinal were assembled in jigs with the transverse bulkheads and web frames to foxm three dimensional grid assemblies.

7.10 After welding of the grid assembly, it was joined to the flat plate blanket to form a complete flat panel block.

7.11 Pin jigs were extensively used for the assembly of curved bilge and side shell units in all shipyards visited.

7.12 A1l structural blocks were mechanically cleaned and painted prior to erection. Only limited capability for reblasting completed blocks was observed.

7.13 Building docks or berths were equipped with multiple erection cranes due to the rapid rate of erection. Many structual blocks were observed in storage waiting for erection.

7.14 Midship blocks were fabricated neat with no stock, and most bow and stern blocks were cut neat at final assembly.

7.15 Extensive use was made of jigs throughout the assembly and erection process.

7.16 Permanent access was designed into non-tight structural members to facilitate access during assembly and erection.

7.17 Heat line fairing, to correct”weld distortion, was observed at all subassembly and assembly stages.

7.18 Large capital intensive jigs or work fixtures had been developed for tanker and bulk carrier construction. These include the following:

a. At the Mitsui Chiba Shipyard, the Rotas System was used for the construction of large 60’ long by 1400 ton wing tanks. These large.blocks were assembled on end, the vertical joints were welded using the electro-slag process, and then the complete block was rotated mechanically for welding in various positions. After the completion of welding, the block was transferred mechanically to the edge of the dock, lowered into the dock, and . transferred mechanically to the erection position.

b. At IHI Kure Shipyard, a mechanical devise for rotahing large flat panels on end and providing mechanical staging was observed. This system was used to allow complete downhand welding of the web”frame to panel connections.

c. At the IHI Kure and Aioi Shipyards, mechanized work units had been developed to provide staging and services as well as mechanical assistance in the erection, fairing, and welding of shell, longitudinal bulkhead, and deck panels on large tanker and bulk carriers.

8.0 Welding

8.1 The welding process is defined very early in the contract and is a key input to the development of functional and detail design.

8.2 Subassembly welding was accomplished using gravity rods. The quality of gravity rod welding appeared excellent.

8.3 Flat panel seams were welded using one side submerged arc welding. The one side welding process was used for thicknesses of 9-30 MM (3/8″- 11/4″) . The welding of the three dimensional grids to the flat plate blanket was accomplished using gravity rods.

8.4 Curved panel seams were welded using submerged arc welding against a temporary backing material. The welding of stiffeners and web frames to curved panels was accomplished using gravity rods.

8.5 It appeared that all fitting was accomplished prioz to releasing the blocks for welding. In some yards the assembly and welding of flat panel blocks was accomplished on a slowly moving floor conveyor.

8.6 Erection welding was based on the maximum use of automatic and semi-automatic welding processes. Typical processes are as follows:

a. Deck plating was welded with submerged arc using temporary backing.

b. Vertical shell and bulllhead butts were welded using the electro-slag process.

c. Sloping or overhead surfaces were welded using oscillating fluxcore or solid wire MIG against temporary backing.

d. Vertical deck longitudinal were welded using the electro-slag process. Deck longitudinal were flat bar to facilitate this process.

e. Bottom shell, side shell and longitudinal bulkhead stiffeners were welded using the electro-slag process for vertical surfaces and the submerged arc process for horizontal surfaces.

9.0 List of Follow-on Projects

The following iS a liSt of fOllOW-On projects identified in our November 151 1979 meeting held in Tokyo, Japan:

(1) Zone Planning - A second edition of The Outfit Planning Manual, covering hull structure and painting. (Priority A)

(2) Zone Planning Exandes - A pamphlet giving lists and sketches of block arrangements, outfit unit arrangements, pallet lists, drawing lists, etc. for a typical IHI ship. (Priority A)

(3) Zone Planning Educational Aids - Implementation aids in written and audio visual form for the use of design and shipyard middle management. (Priority B)

(Ll) Handbook for Production Process Planning and Engineering - A manual on the function and accomplishment of production engineering. (Priority A)

(5) Managing the Plannina Phase - A manual on scheduling_and control of the front-end engineering, material control and planning phase. (Priority B)

(6) Shipbuilding Standards, Long Term Objectives - The development of a long range set of objectives and program for the development of an expanded and comprehensive U.S. Shipbuilding standards program. (Priority A)

(7) Functional Desiun Standards for Diesel Machinery Plants - The development of functional design standards covering low speed diesel power plants. (Priority B

(8) Improved Services in Shops and On Board - A manual on pre-planning services in shops and on board. (Pxiority B

(9) Jigs and Fixtures for Assembly and Erection - A manual on fitting jigs and fixtures for assembly and erection. (Priority 3